

# Evaluation of the Effects of Rest-Rotation Grazing on Greater Sagegrouse Habitat and Population Dynamics in central Montana

## BLM Montana Sage Grouse Grazing Research Study in Montana

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## **BACKGROUND**

The goal of this study is to evaluate the effects of sage-grouse friendly livestock grazing strategies, created by the Natural Resources Conservation Service (NRCS), on the population dynamics of greater sage-grouse (*Centrocercus urophasianus*; hereafter sage-grouse) as well as sage-grouse habitat. Taylor et al. (2012) showed that hen survival, nest success, and chick survival are the 3 most important drivers of population growth in sage-grouse populations. Therefore we evaluate these 3 population vital rates as well as habitat selection between Sage-Grouse Initiative (SGI) contracted lands (hereafter SGI area) with that of hens in areas where there are no SGI grazing systems (hereafter non-SGI areas). In addition to the broad-scale SGI / non-SGI comparison, we categorize all pastures used by sage-grouse into one of four grazing treatments. These treatments have been defined with respect to sage-grouse ecology rather than the grazing system to enable us to extrapolate the results to grazing systems other than SGI systems. The treatments will also provide additional insights into SGI grazing systems and if/how the systems can be improved:

1. Grazed during the nesting season (April 1<sup>st</sup> – July 20<sup>th</sup>),
2. Grazed during brood-rearing (July 21<sup>st</sup> – September 15<sup>th</sup>),
3. Grazed during fall/winter after broods break-up until the start of the next breeding/nesting season (September 16<sup>th</sup> – Mar 31<sup>st</sup>), or
4. Pasture is rested the entire year (Apr 1<sup>st</sup> – Mar 31<sup>st</sup> the following year).

Responses to these grazing treatments also will be evaluated in combination with the previous year's rest history because they may depend on the condition of the pasture when management was implemented. We communicate with non-SGI landowners to obtain grazing information on non-SGI pastures, which enables us to categorize these pastures, in addition to the SGI pastures, into the above treatments.

The research is being conducted on a landscape that includes private, state, and BLM owned land in Golden Valley and Musselshell Counties, Montana. The lands are intermingled in ownership, as is much of the BLM land in eastern Montana, South Dakota, and North Dakota. The sage-grouse fulfills its life cycle and habitat requirements on a landscape that includes all three ownerships. The study area includes approximately 59,867 acres of BLM land.

We have completed 6.5 years (corresponding with 6.5 years since the initiation of SGI) of this 10 year study. Radio telemetry is the main technique we use to collect data on hen survival, nest success, and chick survival. Annual research tasks include capturing and marking adult females (hens) with radio transmitters, finding and monitoring nests, capturing and marking sage-grouse chicks with radio transmitters, and measuring key vegetation characteristics in sage-grouse habitat and in areas with varying grazing treatments and strategies. We collect vegetation data at nests and unused sites in potential sage-grouse nesting habitat to measure the influence of grazing treatments on sage-grouse nest site selection and nest success. A large-scale geographical information system has been created to evaluate resource selection and habitat use by hens and chicks and nest site selection at a larger scale. We also collect vegetation data in rested and unrested pastures independent of sage-grouse locations to determine if and how the grazing treatments impact vegetation in sage-grouse habitat.

#### **NEW PROGRESS: JANUARY 1, 2016 – JULY 7, 2016**

#### **TIMELINE**



*\*\*Years are defined as April 1 through March 31 (e.g., April 1 2015 to March 31, 2016).*

We are half-way through our 6<sup>th</sup> year of data collection for this project. Hens are monitored twice per week from the ground during April – August, and once per month using telemetry flights during September – March (Fig. 1). Several hens have been located on BLM lands (Fig. 2). We began the 2016 nesting season with 98 marked hens after our March-April 2016 capture efforts. Our annual survival estimates of hens are measured from Apr 1<sup>st</sup> at the start of nesting season through March 31<sup>st</sup> each year. Apparent annual survival estimates (number of hens



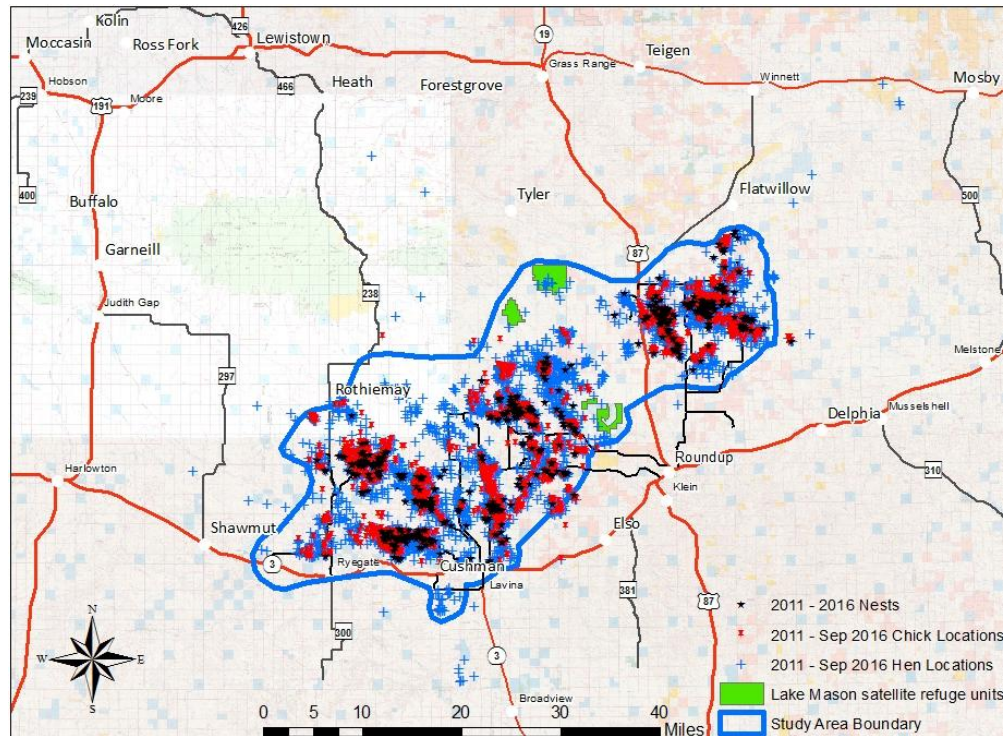


Figure 1. Location of all nests, radio marked chicks, and radio marked hens from 2011 – September 2016 for the greater sage-grouse grazing project in Musselshell and Golden Valley Counties, Montana. The light orange and pink polygons represent BLM lands, the light blue polygons represent State lands, and white polygons represent private lands.

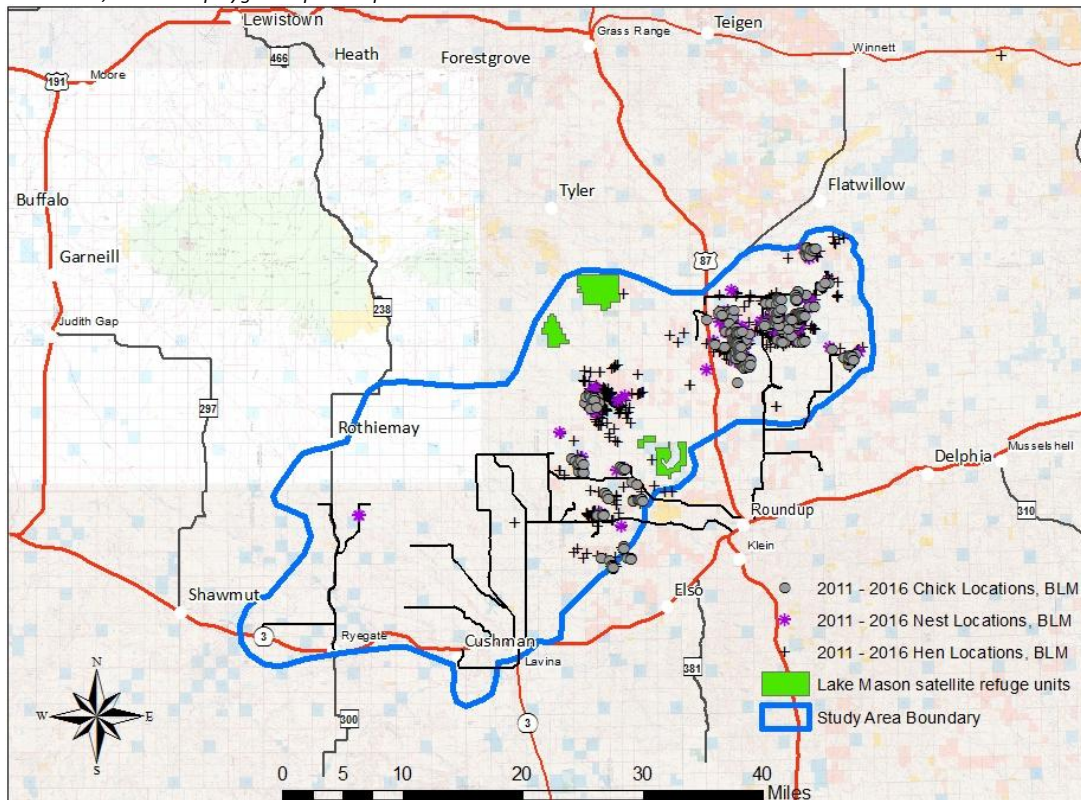


Figure 2. Location of all nests, radio marked chicks, and radio marked hens on BLM lands for the greater sage-grouse grazing project in Musselshell and Golden Valley Counties, Montana, during 2011 – September 2016. The light orange and pink polygons represent BLM lands, the light blue polygons represent State lands, and white polygons represent private lands.

alive at the end of the monitoring period / total number of hens alive at the start of the monitoring period) for all years of our study (Table 1) are comparable to that observed in other studies across the range of sage-grouse (Table 2), though we caution that our estimates in Table 2 are apparent estimates and not formal survival analyses. Hens whose signals were lost are censored from the marked population on the last day their signal was heard. The survival estimate for our marked population of hens in 2016 is on track to be within the observed range of hen survival in other studies.

Year Season	Apr-May (Spring)	Jun-July (Summer)	Aug – Oct (Fall)	Nov – Mar (Winter)	Annual
2011	88%	88%	83%	83%	53%
2012	86%	92%	85%	85%	65%
2013	90%	88%	87%	83%	58%
2014	85%	100%	70%	93%	56%
2015	91%	92%	92%	88%	62%
2016	89%	94%	In progress		

Table 1. Apparent seasonal and annual survival (number of hens still alive / total number of hens monitored) of our marked population of greater sage-grouse hens in Golden Valley and Mussellshell Counties, Montana during 2011 – September 2016 for all treatments combined. Our annual survival is measured from Apr 1 – Mar 31. Hens whose signals are lost are censored from these survival rates on the last day their signal was heard.

Survival Estimate	Location	Reference
75 – 98%	Central Montana, our study area	Sika 2006
48 – 78%	Wyoming	Holloran 2005
48 – 75%	Idaho	Connelly et al. 1994
57%	Alberta	Aldridge and Brigham 2001
61%	Colorado	Connelly et al. 2011
37%	Utah	Connelly et al. 2011

Table 2. Summary of annual adult female greater sage-grouse survival estimates from several studies across the greater sage-grouse range.

We have defined seasons for seasonal hen survival and habitat use to represent biologically meaningful separations *sensu* Blomberg et al. (2013) and herein report seasonal survival estimates for 2016 (Table 1). There are few published seasonal survival estimates available for sage-grouse hens. Our apparent seasonal survival estimates are comparable to seasonal survival estimates measured by Blomberg et al. (2013) in a Nevada population of greater sage-grouse. Blomberg et al. (2013) monitored hen survival for 328 hens from 2003-2011. Their seasonal survival estimates, represented here as mean survival  $\pm$  standard error (SE) were: spring = 0.93 or 93%  $\pm$  0.02; summer = 0.98  $\pm$  0.01; fall = 0.92  $\pm$  0.02; and winter = 0.99  $\pm$  0.01. These seasonal hen survival rates are higher than our apparent survival estimates, but again we caution that our estimates represent apparent hen survival. Blomberg et al. (2013) found very

little annual variation in hen survival, allowing them to pool years and obtain one rate for each season (above). We have yet to evaluate interannual variation in seasonal survival rates and thus present our rates by year. Apparent fall (Aug – Oct 2016) and winter (Nov 2016 – Mar 2017) survival for 2016 from our study is not yet complete at the time of this report.

## **Nests**

### **Nest Site Selection: 2011 – 2015**

Herein we report preliminary results for nest site selection from 2011-2015. Nests are found by monitoring hens marked with radio transmitters via radiotelemetry. To evaluate the effects of vegetation on nest success and nest-site selection, we sample vegetation at nests as well as stratified random points within potential nesting habitat. We use ArcGIS and program R (R Core Team 2011) to generate random points that are constrained to be within 6.4 km of leks, not in cropland, and in a sagebrush-dominated land cover. Nest plots are measured after nests have reached their estimated hatch date (for failed nests) or after the nests successfully hatch. Plots at random points are measured during the same week as nest plots that are in the same area. Local-scale vegetation plots measured in the field are centered on the nest bowl or a random shrub (the shrub nearest to a random point and >35 cm in height) and extend 15 m in each cardinal direction (“spokes”). Much of our protocol for sampling vegetation follows the procedure outlined in Doherty (2008). At the nest or random shrub we measure grass height (maximum droop height with and without the inflorescence, current year’s and residual [previous year’s standing dead] grass); the top two dominant cover species of grass; height, width, species, and percent vigor of the nest or random shrub; and visual obstruction using a Robel pole (Robel et al. 1970). Along each spoke we estimate visual obstruction at 0, 1, 3 and 5 m from the nest or random shrub. Using Daubenmire frames (Daubenmire 1959) at 3, 6, and 9 m from the nest or random shrub along each spoke we measure the height of the nearest shrub; measure the grass height (maximum droop height with and without the inflorescence, current year’s and residual grass); and estimate percent cover of native and non-native live (current year) grass, residual (previous year’s standing dead grass) grass, native and non-native forbs (herbaceous flowering plants), litter (detached dead vegetation, not standing), lichen, moss, bare ground, rock, and cowpies. In each Daubenmire frame, forbs are identified to species and the number of each species is recorded to measure forb species diversity and abundance. For each spoke we also measure sagebrush canopy cover and density using line-intercept and belt transect methods (Canfield 1941; Connelly et al. 2003). Additionally, we measure an index of livestock utilization in each local-scale vegetation plot by measuring the percent of the plot that has been grazed and counting the number of cowpies (both from the current and previous year) in each plot. These data enhance the information we obtain from NRCS and landowners on the grazing history in specific pastures.

In addition to collecting local-scale vegetation data, larger scale vegetation and other habitat data (e.g., distance to roads, Table 3) are measured using remote sensing data from GIS layers (e.g., Table 3) for evaluating the impact of landscape-scale variables on nest site selection and nest success of hens. We collect data on precipitation each year from the Oak Ridge National Laboratory Distributed Active Archive Center, a data center of the National Aeronautics and Space Administration's Earth Observing System Data and Information System (<<https://daymet.ornl.gov/>>).

Table 3. Covariates considered in building nest success and nest-site selection functions (Smith 2012).

Covariate	Resolution	Source	Description
<b>Landscape-scale Covariates: 1000 – 5000 m buffer distance</b>			
Roughness	30 m	DEM	Mean topographic roughness index of specified buffer
% Cropland	30 m	NASS <sup>1</sup>	% of specified buffer classified as cropland (irrigated or non-irrigated)
% Forest landcover	30 m	Landfire 1.1.0 <sup>2</sup>	% of specified buffer classified as forest landcover
% Developed land	30 m	Landfire 1.1.0	% of specified buffer classified as developed (high- or medium-intensity)
Distance to roads	30 m	Tiger/Line <sup>3</sup>	Euclidean distance, in meters to nearest road
Linear distance of roads	30 m	Tiger/Line	Linear density of roads in km/km <sup>2</sup>
<b>Pasture-scale Covariates: 30 – 1000 m buffer distance</b>			
% Shrub landcover	1 m	ORC <sup>4</sup>	% of 1 m cells in specified buffer classified as shrub landcover
% Grass landcover	1 m	ORC	% of 1 m cells in specified buffer classified as native grass landcover
% Barren landcover	1 m	ORC	% of 1 m cells in specified buffer classified as barren landcover
% CRP landcover	1 m	ORC	% of 1 m cells in specified buffer classified as CRP landcover
% Riparian landcover	1 m	ORC	% of 1 m cells in specified buffer classified as riparian vegetation
Bare Ground Cover	1 m	ORC	Mean bare ground cover of specified buffer
Herbaceous	1 m	ORC	Mean herbaceous vegetation cover of



Covariate	Resolution	Source	Description
Cover			specified buffer
Shrub Cover	1 m	ORC	Mean shrub cover of specified buffer
Grazing Treatment	Pasture	NRCS & landowners	Categorical variable representing the grazing treatment of the pasture.
<b>Plot-level Covariates: 0-30 m (measured in the field)</b>			
Shrub % cover		Line-intercept	
Sagebrush % cover		Line-intercept	
Shrub density		Belt transects	
Sagebrush density		Belt transects	
Nest VO		Robel-pole	
Plot VO		Robel-pole	
Herbaceous % cover		Visual estimation	
Bare ground % cover		Visual estimation	
Litter % cover		Visual estimation	
Herbaceous height		Meter stick	
Residual grass height		Meter stick	
Shrub height		Meter stick	
Nest shrub height	At nest	Meter stick	
Nest shrub % vigor	At nest	Visual estimation	
Nest shrub volume	At nest	Calculated	

<sup>1</sup>USDA National Agricultural Statistics Service, 2010 Cropland Data Layer (will be updated as new layers become available)

<sup>2</sup>LANDFIRE 1.1.0 Existing vegetation type layer. USGS (<http://landfire.cr.usgs.gov/viewer/>; will be updated as new layers become available)

<sup>3</sup>Census 2010 TIGER/Line shapefile (<http://www.census.gov/geo/www/tiger/shp.html>; will be updated as new layers become available)

<sup>4</sup>Open Range Consulting Multi Scale Assessment (MSA); Open Range Consulting 2013, Sant et al. 2014

We used Bayesian methods to fit logistic regression models relating measured covariates (Table 3) to the probability that a site was a nest (1) versus a randomly sampled available site (0). We used indicator variables paired with each model coefficient to assess variable importance and



produce model-averaged coefficient estimates (Kuo and Mallick 1997). We performed an initial screening of variables by fitting univariate nest site selection models to each candidate variable and rejecting variables when 85% credible intervals for coefficients overlapped zero. Of the 16 variables passing variable screening, seven were supported with Bayes factors  $\geq 3$  (Fig. 3). These were nest shrub volume, plot-scale (15 m) sagebrush cover, patch-scale (100 m) roughness, patch-scale sagebrush heterogeneity, distance to county roads and highways, distance to two-track roads, and proportion of the landscape (1.61 km) disturbed. At the scale of the nest substrate, females selected shrubs with greater volume. At the plot scale, females selected for greater sagebrush cover. At the patch scale, females selected gentler terrain and more even stands of sagebrush. Finally, females preferred to locate nests farther from county roads and highways but closer to two-track roads, and avoided landscapes with greater amounts of non-cropland anthropogenic disturbance. We do not have a not have a clear biological interpretation of selection of nest sites closer to two-track roads. We speculate that this preference may reflect the tendency for two-track roads to traverse terrain preferred by sage-grouse for nesting, e.g., areas of gentle topography. We found no evidence of selection with respect to herbaceous vegetation metrics, current-year's livestock use intensity, or density of previous-years' cow pats.

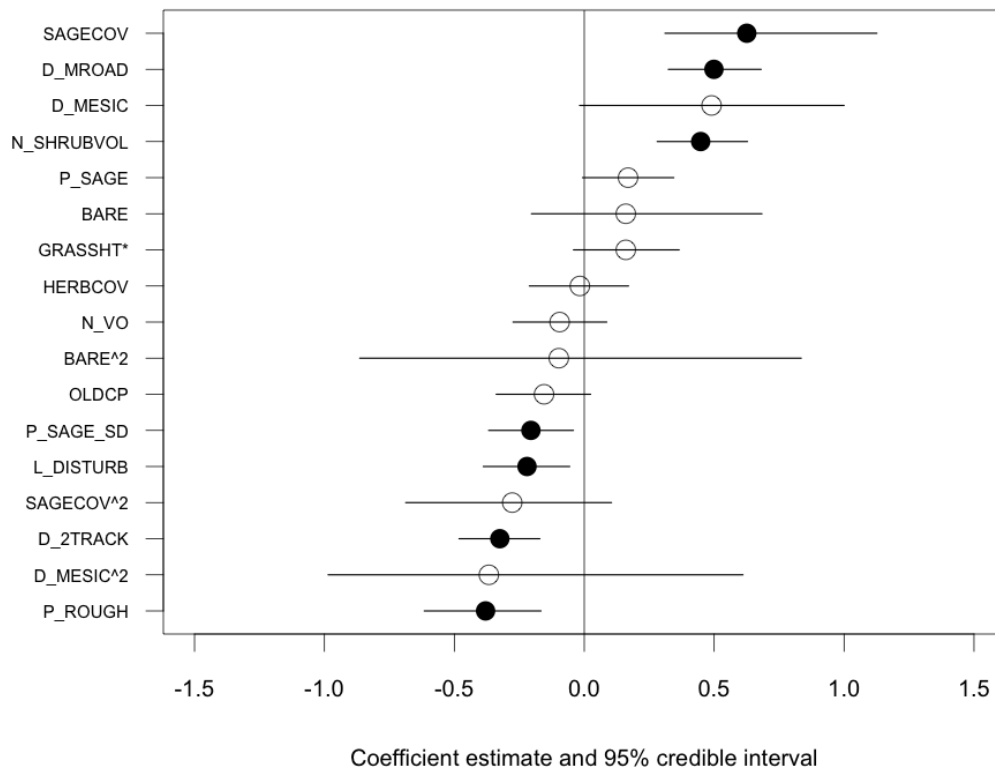


Figure 3. Coefficient estimates from a logistic regression model describing variables influencing the selection of nest sites ( $n=322$ ) by sage-grouse in Golden Valley and Musselshell Counties, Montana, USA from 2012 to 2015. Filled circles identify variables supported by Bayes factors and error bars represent 95% credible intervals. Selection of nest sites was driven not by herbaceous vegetation characteristics but by preference for greater shrub cover (SAGECOV) and size (N\_SHRUBVOL), gentle topography (P\_ROUGH), avoidance of county roads and highways (D\_MROAD), and avoidance of non-cropland anthropogenic disturbance at the landscape scale (L\_DISTURB).

### Nest Success 2016, Progress Since Last Report

We found and monitored 85 nests of hens from our marked population on lands of all ownerships during the 2016 field season (Fig. 1). Since 2011, 122 nests have been located on BLM lands (Fig. 2). Nests were monitored every other day until the nest hatched or failed. Hens that had failed nests were monitored for re-nesting attempts. We considered nests that hatched at least one chick as successful (Table 4).

	2011	2012	2013	2014	2015	2016
Overall Apparent Nest Success	30%	54%	40%	64%	52%	36%
Total Number of Nests	102	91	85	74	77	85
Number of 1 <sup>st</sup> Nests / Nest success	79/28%	82/52%	69/39%	68/63%	69/54%	68/35%
Number of 2 <sup>nd</sup> Nests / Nest success	22/41%	9/67%	15/40%	6/67%	8/38%	17/41%
Number of 3 <sup>rd</sup> Nests / Nest success	1/0%	–	1/100%	–	–	–

*Table 4. Apparent nest success (number of monitored nests that hatched at least one chick / total number of nests monitored) of our marked population of greater sage-grouse hens in Golden Valley and Mussellshell Counties, Montana during 2011 – 2016 (SGL and non-SGL areas combined). Total number of nests monitored are presented as well as number of nests per nest attempt. Nest success for 1<sup>st</sup> nests = # successful 1<sup>st</sup> nests / total 1<sup>st</sup> nests attempted; 2<sup>nd</sup> nests = # successful 2<sup>nd</sup> nests / total 2<sup>nd</sup> nests attempted; 3<sup>rd</sup> nests = # successful 3<sup>rd</sup> nests / total 3<sup>rd</sup> nests attempted.*

Nest success varies from 14 – 86% across the entire range of sage-grouse (including studies from Oregon, Colorado, and Idaho; Connelly et al. 2004). The average nest success across the range is 46% (Connelly et al. 2011). Nest success observed during all years of our study is within the range expected for sage-grouse.

Preliminary numbers show that of the 85 nests we monitored during the 2016 season, 68 were first nests and 17 were second nests (re-nesting attempts from failed first nests; Table 4). There are some hens each year that do not nest. During 2016, 69% of the marked population did attempt to nest at least once (Table 5). Re-nesting attempts of hens have been higher in years when nest failure rate was also higher.

### Nest Success: 2011 – 2016

We used Bayesian methods to fit logistic regression models relating measured covariates to daily nest survival rate. As with nest site selection models, we used indicator variables paired with each model coefficient to assess variable importance and produce model-averaged coefficient estimates, and performed an initial variable screening step, rejecting variables (i.e.,

	2011	2012	2013	2014	2015	2016
Total number of marked hens at the start of the nesting season	101	108	90	91	102	98
Hens attempting to nest out of all marked hens	79% (80/101)	76% (82/108)	79% (71/90)	75% (68/91)	68% (69/102)	69% (68/98)

Table 5. Percent of our marked population of greater sage-grouse hens that attempted at least one nest in Golden Valley and Musselshell Counties, Montana during 2011 – 2015 ( SGI and non-SGI areas combined). \*Total number of marked hens each year is less than 100 after censoring lost signals from the population.

Table 3) when 85% credible intervals for coefficients overlapped zero. We included separate intercepts for each year and a random effect for individual females, as we monitored from one up to seven nests for each female (all nests for an individual from 2011-2015) and fates of nests from the same female may not be independent if females differ in ‘quality’ with respect to their ability to successfully incubate a nest.

Of the 11 variables passed to the final model only precipitation was supported with a Bayes factor  $\geq 3$ , with greater amounts of rainfall over a 4-day period associated with lower daily nest survival (Fig. 4). Distance from county roads and highways received some support from a 95%

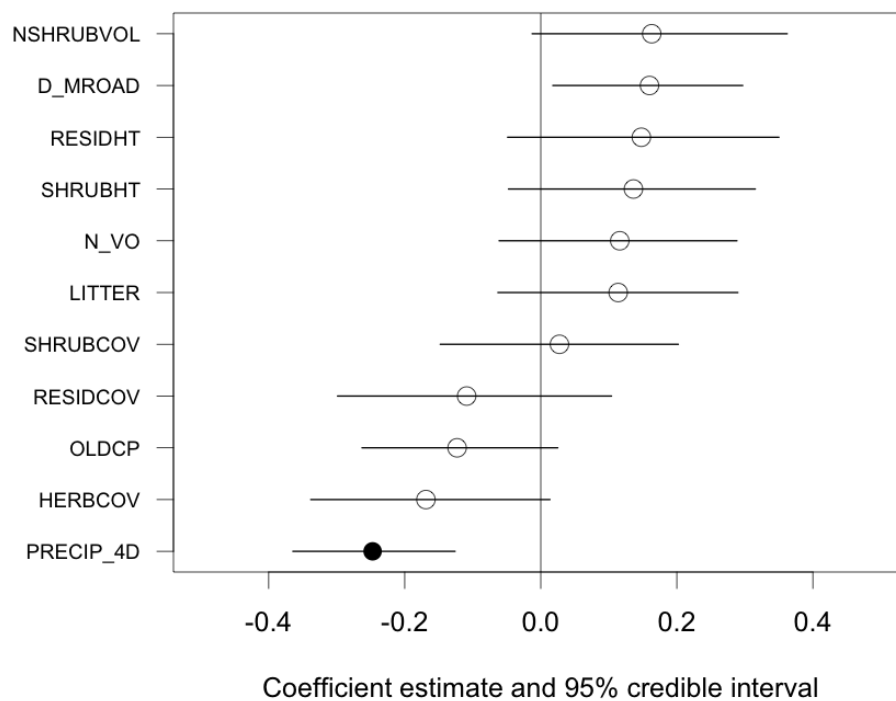


Figure 4. Coefficient estimates from logistic regression model describing variables influencing daily nest survival of sage-grouse nests ( $n=412$ ) in Golden Valley and Musselshell Counties, Montana, USA from 2011 to 2015. Filled circles identify important variables supported by Bayes factors and error bars represent 95% credible intervals.

credible interval that did not overlap zero, suggesting greater survival farther from these features. Grazing system (Non-SGI vs SGI), presence or absence of livestock in the pasture during nesting, current year's grazing intensity, and density of previous-years' cow pats were all unrelated to daily nest survival.

## Chicks

In 2016, we captured 45 chicks at 2 to 8 days old from 25 successful nests and marked them with radio transmitters (no more than 2 chicks per brood were marked). Marked chicks were monitored every other day for the first couple weeks when mortality is highest, and then twice per week thereafter (Fig. 1). During 2011 – 2016, 109 individual chicks from 63 broods have been located on BLM land for a total of 552 locations (Fig. 2).

Only chicks that were known to survive until their transmitter battery failed or were recaptured to be marked with an adult transmitter were considered to survive until the end of the monitoring period. Chicks whose signals were lost and their fates unknown were not considered alive for this estimate. Thus this apparent survival estimate (number of chicks known to be alive / number of total marked chicks) for chicks is conservative at 22% (10/45). These numbers could change as we are cleaning up data. Seven chicks were re-marked with adult collars in Aug – Sep 2016 and continue to be monitored. There were possibly more chicks that survived, but we could not monitor their status because we could not access the private land they were using. Thus these chicks have been censored in analyses.

Apparent survival estimates for sage-grouse chicks during 2011 – 2016 ranged from 12 – 22% (Table 6). We are still cleaning up data, thus these are preliminary results that may be adjusted. Chick transmitters were guaranteed to last 60 days, and most lasted 75 to 100 days. Thus the "Number of Surviving Chicks" (Table 6) is the number of chicks that survived at least 60 days, and in most cases at least 75 days, when they were large enough to be recaptured and marked with an adult radio transmitter (if female; we only mark female adults in this study). If chicks survived and were not recaptured, their monitoring period was up to 100 days.

	2011	2012	2013	2014	2015	2016
Apparent Chick Survival	22%	10%	14%	12%	19%	22%
Number Surviving Chicks	5	8	8	9	11	10
Total Number of Marked Chicks	23	81	57	75	58	45

Table 6. Apparent survival of greater sage-grouse chicks (number of chicks known to be alive at the end of the monitoring period / number of total marked chicks at the start of the monitoring period) in Golden Valley and Musselshell Counties, Montana, USA, during 2011 – 2016 that were known to survive until their transmitter battery failed or were recaptured to be marked with an adult transmitter.

We used package “survival” (Therneau 2016) in program R to run the following Kaplan-Meier survival analyses; we have not incorporated 2016 data into these analyses yet. With data pooled across years, the Kaplan-Meier mean survival time for sage-grouse chicks marked with radio transmitters during 2011 – 2015 was 25 d (SE = 2.67 d), and the median survival time was 13 d (95% confidence interval [CI] = 10 – 16 d; Fig. 5). Individuals whose signals are lost or fates are unknown are censored from the analysis at the last time they were successfully monitored. Thus our Kaplan-Meier survival estimates are conservative.

In the following preliminary analyses, we used log-rank tests to look for differences in survival of marked chicks related to year (2011 – 2015) or grazing treatment of the pastures where chicks hatched (SGI or Non-SGI). Chick survival was not significantly different among years ( $\chi^2 = 5$ ,  $df = 4$ ,  $p = 0.292$ ; Fig. 6). The SGI status of the pastures in which chicks hatched did not impact chick survival during any part of the monitoring period when data for all years was pooled ( $\chi^2 = 0.5$ ,  $df = 2$ ,  $p = 0.784$ ) or when evaluating SGI-status with respect to year (log-rank test stratified by year:  $\chi^2 = 3.1$ ,  $df = 2$ ,  $p = 0.21$ ). However, this is only a first look at where chicks spend their first few days post-hatch. Chicks may move between SGI and Non-SGI pastures throughout the monitoring period, and a different analysis is needed to estimate

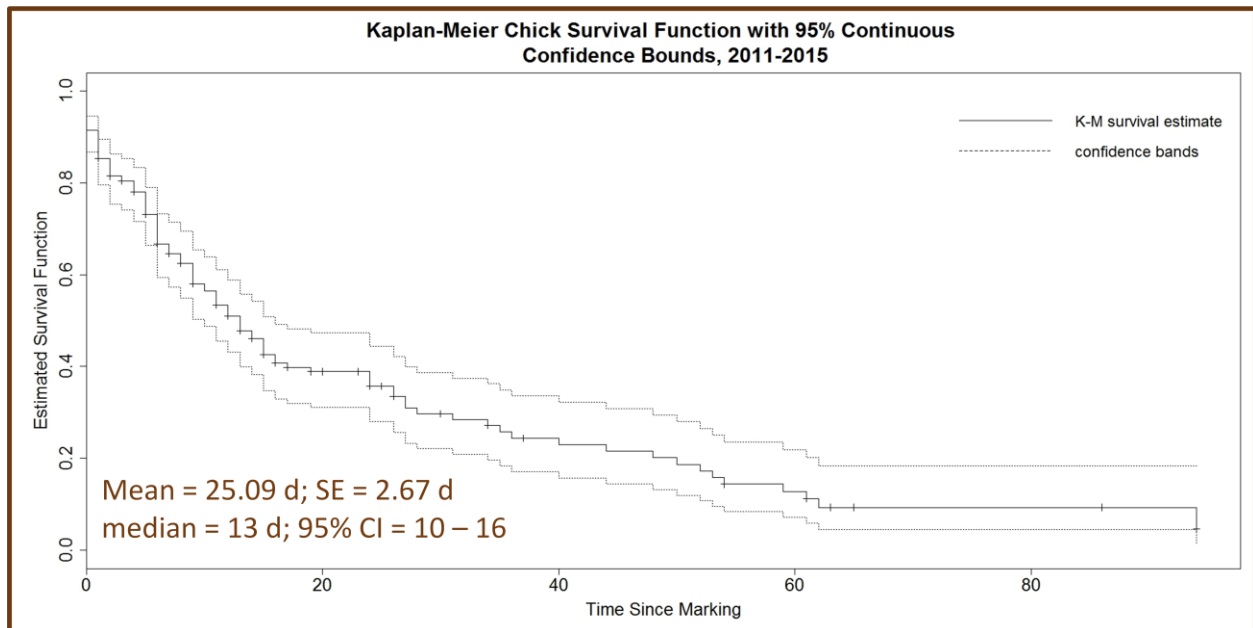


Figure 5. Kaplan-Meier survival curve and 95% confidence bounds for greater sage-grouse chicks marked with radio transmitters in Golden Valley and Musselshell Counties, Montana, USA during 2011 – 2015. Mean survival time for marked chicks was 25 days (SE = 2.67 days), while the median survival time was 13 days (95% confidence interval = 10 – 16 days).

survival instantaneously during each monitoring interval throughout the period as well as allow the grazing status of the pastures to also change throughout each interval of the monitoring period. These analyses will be completed in the next couple years.



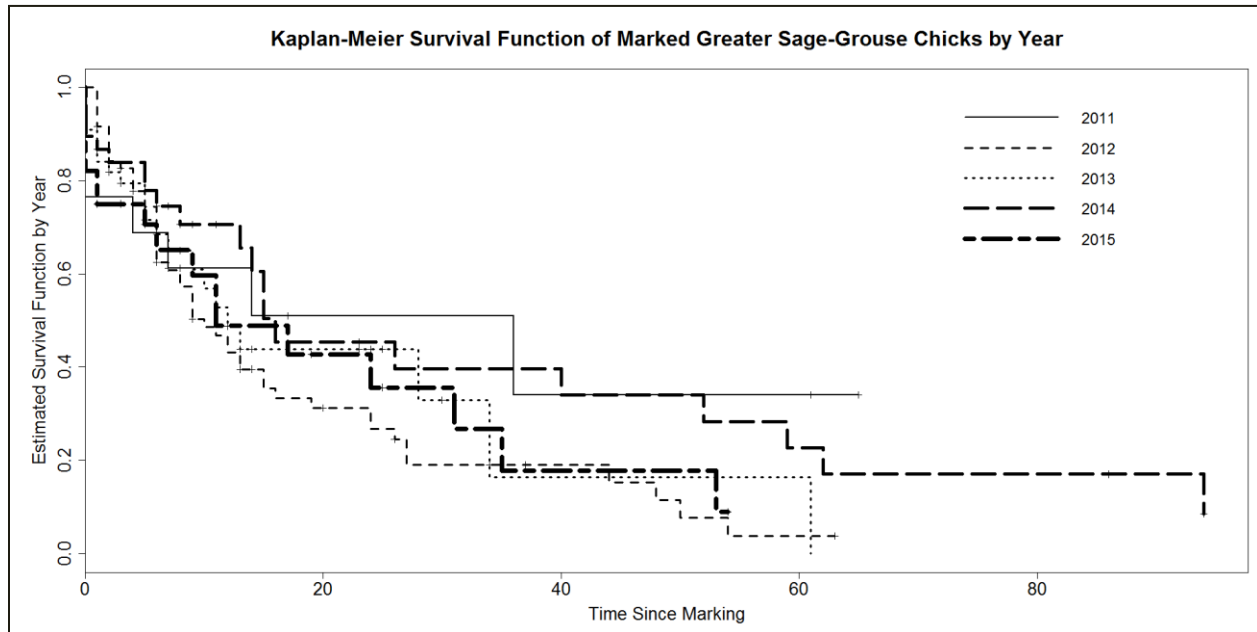


Figure 6. Kaplan-Meier survival curve by year for greater sage-grouse chicks marked with radio transmitters in Golden Valley and Musselshell Counties, Montana, USA during 2011 – 2015. The 95% confidence bounds are not shown in order to make the survival curves easy to see. Chick survival was not different among years ( $\chi^2 = 5$ ,  $df = 4$ ,  $p = 0.292$ ).

Weather conditions during the sensitive post-hatch time, which peaks in early June for many prairie grouse, may have a large impact on chick survival (Flanders-Wanner et al. 2004). For example, chicks cannot thermoregulate during their first week post-hatch and rely on the hen to keep them warm. Many chicks get chilled and die during heavy rain events during the post-hatch period ([Horak and Applegate 1998](#)). We have not yet formally analyzed the effects of weather and other habitat variables on chick survival. Previous studies have shown chick survival to be variable and range from 12-50% during the first few weeks after hatching ([Aldridge and Boyce 2007](#), [Gregg et al. 2009](#), [Dahlgren et al. 2010](#), Guttery et al. 2013). However, caution should be used when comparing estimates among studies because the duration of monitoring periods differ. For example, Gregg et al. (2009) and Dahlgren et al. (2010) monitored sage-grouse chicks for 28 and 42 days, respectively, whereas we are able to monitor chicks up to 100 days due to the recent availability of smaller, lighter radio transmitters with longer battery life. In addition, some studies measure “brood” survival (at least one chick from a brood lives) or unmarked chicks rather than monitoring individually marked chicks. Unmarked chicks are difficult to observe and monitor, and brood mixing may occur that results in broods containing chicks not parented by a particular hen. Thus there are limitations when comparing unmarked chick or brood survival estimates with telemetry survival estimates. The low chick survival observed during our study suggests a focus for future research and conservation efforts. We are working on chick resource selection and survival analyses to determine how habitat variables impact survival and resource selection in order to help guide

management for this life phase. We are also evaluating hen survival, nest success, chick survival, and the habitat needs for these life phases together to identify priority areas for conservation efforts.

## Vegetation

In addition to monitoring sage-grouse in 2016, we completed 245 stratified random vegetation plots to assess the response of vegetation to different grazing treatments (hereafter “vegetation response” plots; grazing treatments=SGI-grazed, SGI-rested, and non-SGI treatments; Fig. 5). Thirty-one of these plots were located on BLM land (Fig. 6). For all years 2011 – 2016 we have completed 1,199 vegetation response plots (Fig. 5), with 120 of these plots on BLM land (Fig. 6). During 2016, we also completed 199 vegetation plots at nests and random points within nesting habitat (hereafter “nest vegetation plots”; Fig. 5) to evaluate nest site selection by hens. Nineteen of these plots were located on BLM land (Fig. 6). For all years 2011 – 2016 we have completed 1,327 vegetation response plots (Fig. 5), with 122 of these plots on BLM land (Fig. 6).

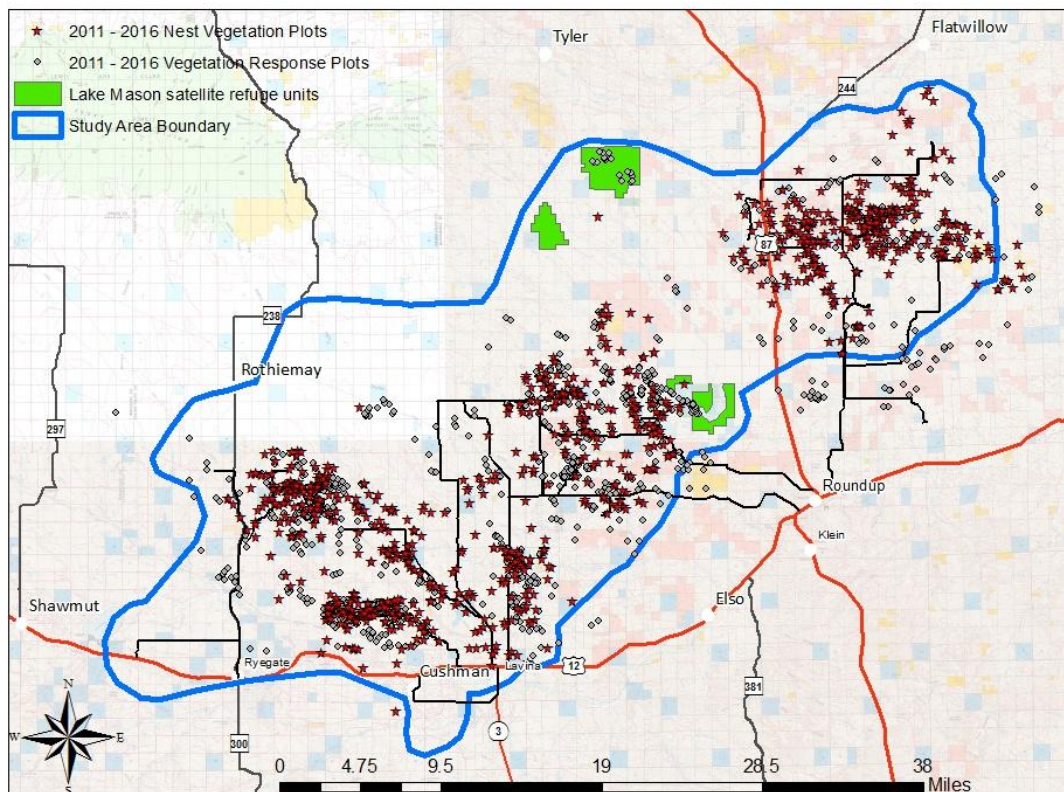


Figure 5. Locations of 2011 – 2016 nest vegetation and vegetation response plots for the greater sage-grouse grazing project in Musselshell and Golden Valley Counties, Montana. The light orange and pink polygons represent BLM lands, the light blue polygons represent State lands, and white polygons represent private lands.

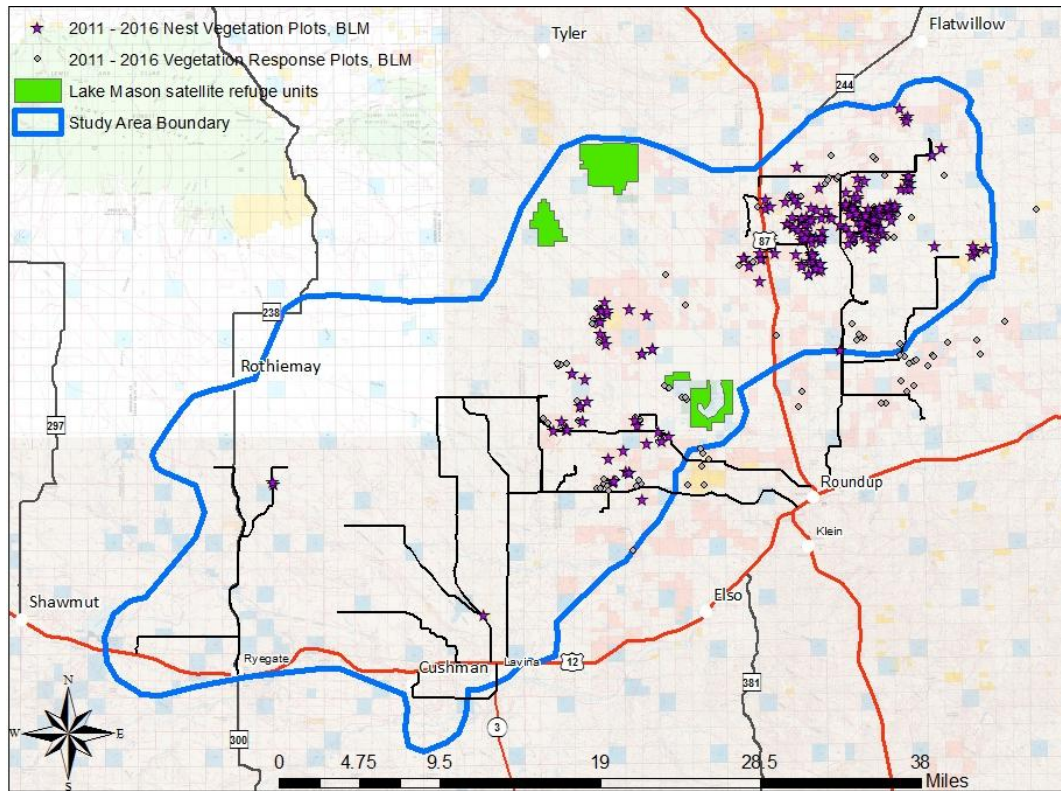


Figure 6. Location of 2011 – 2016 nest vegetation and vegetation response plots for the greater sage-grouse grazing project on BLM land in Musselshell and Golden Valley Counties, Montana. The light orange and pink polygons represent BLM lands, the light blue polygons represent State lands, and white polygons represent private lands.

## Partnerships

We have had ongoing communication with landowners, and hosted our annual landowner appreciation dinner in July 2016—this dinner was attended by John Carlson from BLM. We have continued our partnership that we began in 2014 with USFWS to expand our habitat sampling to the Lake Mason satellite units of the Charles M. Russell (CMR) National Wildlife Refuge in Musselshell County. USFWS is planning to implement SGI systems on the refuge units within the next couple years. We will continue sampling during the 2017 season.

We also continue our partnerships with two other projects on our study area: (1) “Assessing Land Use Practices on the Ecological Characteristics of Sagebrush Ecosystems: Multiple Migratory Bird Responses” by Dr. Victoria Dreitz from The University of Montana, and (2) “Quantifying the Influences of Rest Rotation, Deferred, and Season Long Livestock Grazing on Food Insects of Sharp-tailed grouse and Sage-grouse, Rangeland Pollinators, Dung Beetles, and Plant Communities” by Dr. Hayes Goosey from Montana State University. We successfully attained funding to continue these projects for the next five years, coincident with the minimum duration of this sage-grouse grazing study. We anticipate a collaborative report among the three projects in the next three to five years in which we will assess grazing impacts

on sage-grouse, songbirds, and insects, and connection among these components of the sagebrush ecosystem.

We have partnered also with Montana State University on a project evaluating the impacts of grazing on the demography, population dynamics, and habitat selection of sharp-tailed grouse (*Tympanuchus phasianellus*); densities and demographic performance of the grassland bird communities; and the predator community in Richland County, Montana. This project is very similar in design to our sage-grouse grazing study and will provide a comparison of the impacts of grazing among related species and ecosystems. This project focuses on a three pasture rotation grazing system managed by FWP, and we should be able to make some comparisons among this system, SGI, and more traditional season-long systems. This collaborative approach is essential to understand multiple facets of the impacts of grazing on rangelands and wildlife, and it further leverages funding contributions for this project. It is also a unique and critical opportunity to determine the long-term impacts of changes in land-use practices at the ecosystem level.

### **Professional Activities Completed**

Our research group completed the following:

- Successfully attained funding from the Safari-Club International large grants program for a collaborative proposal with Dr. Victoria Dreitz for sage-grouse / songbird work in the Roundup study area. This was an invited proposal: \$50,000 in 2017, with potentially an additional \$50,000 each year during 2018-19 contingent upon availability of funds.
- Landowner appreciation dinner, Roundup, MT, July 29, 2015.
- Invited presentation at the National SGI SWAT annual training in Lewistown, MT Jun 27-29, 2016 to several agency representatives from USFWS, BLM, NRCS, etc as well as the SGI SWAT biologists working in all states across the range of sage-grouse.
- Invited presentation to the Yellowstone Valley Audubon in Billings, MT, April 18, 2016.
- Provided annual and biannual progress reports to funders: USFWS and FWP for Pittman-Robertson and license funds, respectively; Intermountain West Joint Venture and Pheasants Forever (final report); USFWS, Lake Mason NWR (Bridget Nielsen) for Inventory & Monitoring Program funding.
- Provided regular updates throughout the year to private landowners and our oversight committee.



## **Activities for the Next Year**

We will continue monitoring hen survival, nest success, chick survival, and habitat use during 2017. We will continue to work on analyses and to communicate the progress of our study to landowners, our oversight committee, partners/funders via regular communication and formal written updates, and presentations as requested. We will host our annual oversight committee meeting in Feb 2017, and our annual landowner appreciation dinner in June 2017.

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